AP Chemistry
Thermodynamics Example Problems

1. A gas that is initially at a pressure of 10.0atm and having a volume of 5.0L is allowed to expand at constant temperature against a constant external pressure of 4.0atm until the new volume is 12.5L. Calculate the work done by the gas on the surroundings.

2. Calculate the work done on the system when 6.0L of a gas is compressed to 1.0L by a constant external pressure of 2.0atm.

3. A gas is allowed to expand at constant temperature from a volume of 10.0L to 20.0L against an external pressure of 1.0atm. If the gas also absorbs 250J of heat from the surroundings, what are the values of q, w and ΔE?

4. From the following equations and the enthalpy changes,
   a. $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H^\circ_{rxn} = -393.5$ kJ
   b. $H_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow H_2O_{(l)}$ $\Delta H^\circ_{rxn} = -285.8$ kJ
   c. $2C_2H_{2(g)} + 5O_{2(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(l)}$ $\Delta H^\circ_{rxn} = -2598.8$kJ

   calculate the standard enthalpy of formation of acetylene (C_2H_2) from its elements:

   $2C_{(graphite)} + H_{2(g)} \rightarrow C_2H_{2(g)}$

5. Verify your result from question 4 using standard enthalpies of formation.

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1. A gas that is initially at a pressure of 10.0atm and having a volume of 5.0L is allowed to expand at constant temperature against a constant external pressure of 4.0atm until the new volume is 12.5L. Calculate the work done by the gas on the surroundings.

$-30\ L\,atm \times \frac{101.3\ J}{1\ L\,atm} = \boxed{-3.0\times10^{3}\ J}$

$W = -P\Delta V$

$W = (-4.0\ atm)(12.5\ L - 5.0\ L) = \boxed{-30\ L\,atm}$

2. Calculate the work done on the system when 6.0L of a gas is compressed to 1.0L by a constant external pressure of 2.0atm.

$W = -P\Delta V = -2.0\ atm\ (1.0\ L - 6.0\ L)$

$= \boxed{10\ L\,atm = 1.0\times10^{3}\ J}$

3. A gas is allowed to expand at constant temperature from a volume of 10.0L to 20.0L against an external pressure of 1.0atm. If the gas also absorbs 250J of heat from the surroundings, what are the values of q, w and ΔE?

$W = (-1.0\ atm)(20.0\ L - 10.0\ L) = \boxed{-10\ L\,atm = -1.0\times10^{3}\ J}$

$\boxed{q = 250\ J}$ $\Delta E = q + w = 250\ J - 1000\ J = \boxed{-750\ J}$

4. From the following equations and the enthalpy changes,
   a. $C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H^{\circ}_{rxn} = -393.5$ kJ
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   calculate the standard enthalpy of formation of acetylene (C_2H_2) from its elements:

   $2C_{(graphite)} + H_{2(g)} \rightarrow C_2H_{2(g)}$

reverse c) $4CO_{2(g)} + 2H_2O_{(l)} \rightarrow 2C_2H_{2(g)} + 5O_{2(g)}$ $\Delta H^{\circ}_{rxn} = +2598.8$ kJ

multiply a) by 4 and b) by 2

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$ $\Delta H^{\circ}_{rxn} = -571.6$kJ

$4C_{(graphite)} + 4O_{2(g)} \rightarrow 4CO_{2(g)}$ $\Delta H^{\circ}_{rxn} = -1574.0$ kJ

add them up to get $4C_{(graphite)} + 2H_{2(g)} \rightarrow 2C_2H_{2(g)}$ $\Delta H^{\circ}_{rxn} = +453.2$kJ or divide by 2 to get $\Delta H^{\circ}_{rxn} = +226.6$kJ

5. Verify your result from question 4 using standard enthalpies of formation.

$\Delta H^{\circ}_{f} = (+227) - (4(0) + 2(0)) = \boxed{+227\ kJ}$